

Quality Assurance Considerations for the Implementation*
of a Pulsed Power R&D Project

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Abstract

The second generation Particle Beam Fusion Accelerator (PBFA II) at Sandia National Laboratories (SNLA) is a \$48.15M construction project that includes conventional facilities such as buildings as well as state-of-the-art pulsed power designs and special support systems. The project also includes considerations for longer term program goals, such as breakeven fusion reactions. This project started in May 1980 and is scheduled for completion in January 1986. Implementation of Quality Assurance (QA) policies, techniques and programs, although not a straightforward problem for this complex project, has been effective as demonstrated by progress thus far. The discussion will describe key features of the QA program, their implementation and the results.

Introduction

The goal of the PBFA II Quality Program is to furnish the Department of Energy (DOE) a facility, accelerator and support systems of the highest quality commensurate with the cost and schedule constraints of the project. "Quality" includes

- Performance
- Reliability
- Operability
- Maintainability
- Safety

Implementation of the PBFA II Quality Program through specific requirements and procedures is intended to maintain the control required to assure quality and assure responsible managers that control is being maintained, while allowing the flexibility necessary to a research and development project.

The PBFA II Quality Program includes oversight of all aspects of the PBFA II Project and is in effect from the first stages of criteria development through final assembly and test. The Quality Plan documents policies established and approved by the Project Team, mandatory procedures that implement policy, recommendations and guides for project participants and specific assignment of responsibilities.

Responsibility

Responsibility for the quality of PBFA II as a whole rests with the Project Team. Execution of Project Team decisions and directives is the responsibility of Project Leaders. The Project Leader for Systems Integration is responsible for carrying out quality requirements that apply to the accelerator and unique support systems. The Project Leader for the Facilities Integration is responsible for carrying out quality requirements that apply to the facility and standard utilities.

The decision to make the Project Team--rather than a separate organization--responsible for the quality of PBFA II is based on two arguments:

- This approach emphasizes and helps implement the basic management philosophy of infusing the entire project with concern for quality.
- Because of the nature of the project, each team member has a vested interest in producing a high-quality facility. Therefore, there is no conflict of interest.

Quality Control Elements

A control element is a component of the Quality Program that provides methods and processes to evaluate and control a particular aspect of the project. The following control elements are included in the PBFA II Quality Program:

- Design Control
- Documentation Control
- Configuration Control
- Procurement Control
- Inspection and Test
- Health and Safety

Design Control

The purpose of design control is to ensure that the PBFA II designs support the project objective: constructing facilities, support systems and an accelerator that is theoretically capable of igniting a fusion target. All designs generated for the PBFA II project are subject to review, approval and control by the Project Team.

Design in the PBFA II project is divided into three major types of construction:

- Special Construction (particle beam accelerator and unique support systems)
- Conventional Construction (buildings, standard utilities and support systems)
- Occupancy Construction (extension of standard utilities to the particle beam accelerator and unique support systems).

QA policies, procedures and programs have been established and operational for many years at SNLA, but the Special Construction QA program has been developed especially for the PBFA II project. This paper primarily expounds on the Special Construction QA plan.

Special Construction Design Phases: The design process for special construction as defined for the PBFA II project consists of phases that lead to the following stages of design:

1. Criteria
2. Preliminary Design
3. Final Design

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Design Reviews: Because the Central Project Office (CPO) authorizes work by issuing "work packages," designs are controlled at the work package level. Design control is exercised primarily by design review. Each work package that includes design work progresses through a series of reviews: 1) criteria review, 2) preliminary design review, 3) final design review, and 4) final drawing approval and sign-off.

The Project Leader for Systems Integration invites all Functional Representatives to the reviews, along with other appropriate individuals and "experts" to obtain the best critique possible for a given system. After the review, the design documentation is transmitted to all Project Team Functional Representatives (FR) with an approval sheet. The FRs then have the opportunity to officially approve the design or express concerns. Any conflicts are immediately dealt with by the appropriate FRs and the Systems Integration Manager. If the issues cannot be resolved at that level, they are escalated to the next management level. We have discovered that the FRs take a thorough and critical look at the design documentation before they are willing to sign their approval.

Format of Design Reviews: Another aspect of our review process is that specific formats for each review have been established. In the early stages of the project, we found that project team members had widely different perceptions of what constituted a "review." Therefore, specific formats of what should be included in the review to satisfy everyone's concerns were developed by the CPO and the Project Team. These formats have helped to establish standards of excellence for the Project Team to follow. We have found that, in general, work packages are in much better condition when the responsible people have followed the suggested formats. This is primarily because the formats provide interface information to other members of the Project Team on a timely basis.

Documentation Control

The purpose of documentation control is to ensure that all documentation is current, has been reviewed and approved, and is available to those doing the work. A controlled document is one that is subject to formal review and approval and, once approved, may not be changed without Project Team authorization. Examples of specific documents controlled in the PBFA II project are:

- Criteria Documents
- Design Review Documents
- Engineering Drawings
- Specifications
- PBFA II Baseline Document
- PBFA II Quality Plan and Guidelines
- DOE-required Documents (Project Plan, etc.)

The CPO maintains a distribution list for each controlled document that has been released. Each recipient on the distribution list receives updates if changes are made. The updates may be in the form of change pages, addenda or entire revised documents.

Engineering drawings that have been officially approved include signature blocks. A drawing that has been signed is shown to be controlled and is not subject to change without an approved Configuration Change Request (CCR).

Configuration Control

The purpose of configuration control is to provide a mechanism for making necessary and/or desirable changes in a reasonable time; control all aspects of the project baseline; ensure that the Project Team and upper management recognize the effects that any proposed change will have on cost, schedule and performance; and document the changes.

All documents, designs, hardware or other items essential to achieving the goals of the PBFA II project are subject to configuration control. Examples of items subject to configuration control are accelerator technical parameters, milestone schedules, work breakdown structure, cost estimates, configuration drawings and models, released drawings and specifications, and design review documentation.

To change the configuration of any controlled item, a CCR must be prepared and approved by the appropriate Project Team members, as determined by the Systems Integration Manager. The CCR must describe the requested change, the reason, and the impact of the change on cost, schedule and performance.

Once a CCR is approved, changes can be made to the affected drawings and an Engineering Change Order (ECO) is prepared that describes in detail the changes made to a drawing. The ECO not only documents the changes, but also serves as a basis for negotiations by Purchasing.

Procurement Control

The purpose of procurement control is to ensure that procurement packages contain the necessary quality provisions and that suppliers and subcontractors meet PBFA II quality requirements. It is project policy that all procurements are reviewed and controlled to ensure that appropriate quality provisions are included.

In procurements involving items difficult to manufacture or critical to the performance of PBFA II, the Project Team may decide to survey vendors and compile a list of qualified bidders. Such surveys determine whether potential vendors are capable of fabricating hardware to PBFA II quality specifications.

Selection of appropriate quality provisions to include in Purchase Requisitions (PR) is essential to the success of the project. Lax requirements could jeopardize the performance of the accelerator, while overly stringent requirements could introduce unnecessary costs.

Quality provisions may be included in PRs by referencing specific Engineering Procedures (EP) of the Sandia National Laboratories Engineering Manual. Each EP requires that contractors have inspection or quality programs that meet certain standards. The EPs do not specify methods that must be used to meet the requirements.

Inspection and Test

The purpose of inspection and test is to ensure that materials, fabricated parts, subsystems and the entire accelerator are acceptable for use as an operable particle beam research facility. Inspection and test can be implemented by imposing inspection/test requirements on suppliers and establishing procedures for assembly and test at Sandia.

Different approaches to inspection and test are required for materials and fabricated parts as compared to construction and assembly. Because a formal inspection and test program is a minimum requirement for obtaining satisfactory parts and materials, all materials and fabricated parts to be used in the PBFA II project are subject to an inspection/test program.

Several options may be taken to satisfy inspection/test requirements; some of these are inspection/test by suppliers, in-process inspection/test by a Sandia representative, final field inspection by a Sandia representative, inspection by Sandia Receiving, or inspection/test after receipt by the PBFA II project. As a final check on the inspection/test process, the Work Package Manager (WPM) for each item of hardware countersigns the inspection report received with each shipment. This signature indicates that the WPM has made an appropriate level of inspection on the received hardware.

All measurement and test equipment used to verify products and components for PBFA II must be calibrated. The calibration program includes calibration traceable to the National Bureau of Standards, a recall system to ensure periodic calibration and documentation to show calibration history of all items of equipment to show the expiration date of the latest calibration.

Beyond the minimum requirement of a formal inspection and test program, the manufacturing process is most likely to yield high quality products if representatives of the PBFA II project maintain personal, informal, frequent contact with suppliers. Although the Quality Program does not make such contracts mandatory, both the Quality Program and project management encourage WPMs to keep in touch with suppliers, especially suppliers of critical items.

Health and Safety

The purpose of health and safety activities in the PBFA II project is to minimize the risks of accidents. This is done by early detection of significant potential hazards inherent in the design of the PBFA II conventional and special facilities. Following assessment of the impact of identified hazards on the health and safety of employees and the public, technical and management methods are used to eliminate accident risks or control them at an appropriate level.

A Preliminary Safety Analysis Report (PSAR) was prepared early in the project and concluded that neither the public nor the environment would be exposed to significant risk. A Final Safety Analysis Report (FSAR) has recently been started and will take into account design changes made since the PSAR was prepared.

Attention to health and safety in the design of PBFA II is ensured by the inclusion of a health physicist and a safety engineer who are assigned to the Project Team in the matrix management style. The approval process for project designs routinely includes review and analysis by the health physics and safety representatives.

The PBFA II project includes development of safe procedures and operating guidelines for the PBFA II facility. Specific assignments in the work package for this area include procedures for assembly and test crews, handling of tour groups during construction, provision of necessary safety equipment, and ensuring that proper procedures and guidelines are followed.

Quality Assurance Elements

Quality assurance elements provide the evidence needed for confidence that the quality control functions are being adequately performed. The PBFA II Quality Program includes the following assurance elements:

- Nonconformance and Corrective Action
- Records
- Verification and Audits

The purpose of nonconformance and corrective action procedures is to ensure that variances from PBFA II criteria are documented and are resolved so as to result in a facility that will perform satisfactorily and safely. Resolution of any nonconforming condition must satisfy specific guidelines: 1) Items must be capable of performing their required functions safely; 2) multiple-quantity items must be totally interchangeable, both functionally and physically; 3) items installed in the PBFA II facility must be safely accessible for operation and maintenance. Suppliers are made aware of requirements for nonconformance and corrective action procedures through contract documents, particularly Sandia Engineering Procedures.

Records

The purpose of record keeping procedures is to assure the collection, retention and maintenance of records that document the results of quality-related actions. Examples of records generated during the PBFA II project and officially maintained by the CPO or other delegated persons or organizations are controlled documents; quality-related documents submitted by contractors; and quality-related documents, such as receiving reports created at Sandia. To ensure that proper records of received hardware are kept, the Purchasing and Inventory Controller maintains a file of inspection reports received from suppliers with shipments of hardware.

Verification and Audits

The purpose of verification and audits is to assure that the requirements of the PBFA II Quality Plan and of quality-related procedures are implemented and effective.

An independent Quality Assurance Review of the PBFA II Quality Plan and Project was performed by a Department of Energy (DOE) committee on August 8-9, 1984. The review findings were very favorable and specific, especially in the areas of design control, procurement control, configuration control and software quality assurance. No recommendations for improvement were made at that time.

Results

The results of the PBFA II Quality Program have been very positive thus far. Some specific examples of these results are:

1. There were no major redesigns of tearouts during the facility construction. This is attributed to the review process and also to our program of scale modeling, which has been in place from the beginning of the project. The modelers caught several deficiencies, which were corrected before they became problems.
2. A major contract that was one of the first tests of our engineering talent, review process and Quality Program was the accelerator tank. The contract value for the tank was \$1.5M and change orders were less than 5% for the life of the contract.
3. The entire energy storage section for the PBFA II accelerator was assembled by December 1984, on time and within budget, and change orders for this section were negligible.
4. The Davidson Committee, an external, independent review group of experts in Pulsed Power and beam transport, reviews SNLA's ICF program annually and reports back to SNLA and DOE's Office of Inertial Fusion. They recently issued a report that described the PBFA II engineering effort as outstanding.